Emerging field of few-layered intercalated 2D materials

Qing Cao, Siegfried Eigler
Freie Universität Berlin, Altensteinstraße 23a, D-14195, Berlin, Germany
qing.cao@fu-berlin.de; siegfried.eigler@fu-berlin.de

Abstract
Intercalation is an effective way to tune the physical and chemical properties of 2D materials, thereby facilitating the development of next-generation energy storage and optoelectronic devices, including batteries, sensors, transistors, and electromotive adjustable displays. Among all the 2D materials intercalation compounds, $FeCl_3$ intercalation compounds are most investigated owing to their stability under ambient conditions.[1] However, high uniformity and a high degree of intercalation are critical to the properties and applications of $FeCl_3$ intercalation compounds. In our recent work, we successfully prepare a homogeneous stage-1 $FeCl_3$-bilayer (2L) graphene intercalation compound by inserting a few layers of hBN as protective layer on top of 2L graphene, which are good prototype materials for property investigations and further exploratory studies. In addition to the traditional intercalation methods, we expand the term intercalation beyond the traditional process of atoms or ions penetrating the channels of layered compounds. We propose artificial assembly, a structure that can also be called a van der Waals (vdW) structure. The structure to be fabricated is not limited to certain ions or small molecules but any guest embedded in a specific host, such as a three-dimensional intercalant fullerene or a layer of 2D materials inserted between the layers of other 2D materials.[1] In our recent works, we fabricate graphene/functional groups/MoS_2 (F-G/MoS_2) intercalated structures. The functional groups between graphene basal plane and MoS_2 act as intercalants, which not only introduces the p-doping effect to MoS_2 but also effectively enlarges the interlayer distance and weakens the vdW interaction of the two single layers, thus enhancing the photoluminescence of MoS_2.[2] Hence, artificial assembly has the opportunity to integrate novel building blocks for the fabrication of few-layer intercalation compounds and gain more control over the chemistry that can be induced close to the surface.

References

[1] Q. Cao, F. Grote, M. Huβmann and S. Eigler, Nanoscale Adv., 3 (2021), 963-982.
[2] Z. Wang, Q. Cao, K. Sotthewes, Y. Hu, H. S. Shin and S. Eigler, Nanoscale, 13 (2021), 15464-15470.

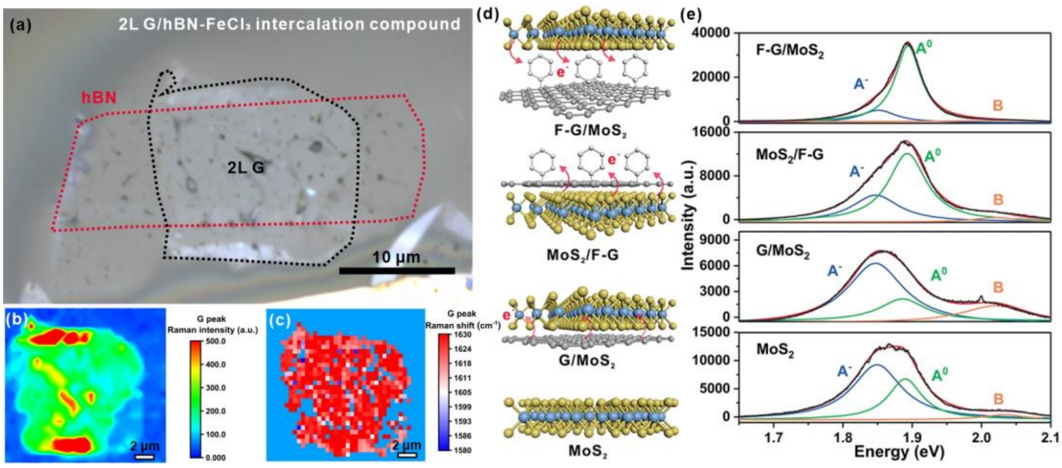

Figure 1: (a) Microscope image, (b) G peak Raman intensity mapping, and (c) G peak Raman shift mapping of 2L G/hBN-$FeCl_3$ intercalation compound. (d) Interfacial interaction mechanism in the structures: F-G/MoS_2, MoS_2/F-G, G/MoS_2, and MoS_2. (e) Peak fittings using Lorentz functions for the above structures.